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ABSTRACT

This digest focuses on reforming mathematics instruction for English-as-a-Second-Language (ESL) students who have had limited or interrupted schooling in their first language. These students--referred to as ESL literacy students--must learn in a linguistically and culturally unfamiliar environment, construct understanding without the background knowledge that their classmates employ to make assumptions, and process new information. They must have access to math content from the beginning of their formal education. This calls for modifications in the delivery of instruction. By integrating math and language teaching, innovative courses can provide experiences that bridge gaps in literacy students math knowledge and expand their communicative competence in English, and ultimately prepare them for success in future math coursework. The digest discusses correlating mathematics instruction with language skills building, the National Council of Teachers of Mathematics standards and effective instructional strategies for literacy students, designing appropriate math curricula for literacy students (including clustering objectives and considering three important variables: students' ages, English proficiency levels, and developmental levels), and assessing literacy math students' progress. (JL)

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Digest

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Reforming Mathematics Instruction for ESL Literacy Students

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English as a second language (ESL) students who have had limited or interrupted schooling in their first language–whom we refer to as *literacy students*–can be overwhelmed by new experiences in ESL and content courses. They must learn in a linguistically and culturally unfamiliar environment, construct understanding without the background knowledge that their classmates employ to make assumptions, and process new information. All too often, these circumstances lead to frustration for both literacy students and their teachers.

Literacy students must have access to math content from the beginning of their formal education. This calls for modifications in the curricula and in the delivery of instruction. By integrating math and language teaching, innovative courses can provide experiences that bridge gaps in literacy students' math knowledge, expand their communicative competence in English, and ultimately prepare them for success in future math coursework.

Correlating Mathematics with Language Skills Building

In response to the call for the reform of mathematics education in the United States, the National Council of Teachers of Mathematics (NCTM) established a Commission on Standards for School Mathematics in 1986. This led to publication of *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989), which included 54 standards among four divisions: Grades K-4, 5-8, 9-12, and evaluation. The NCTM standards established five goals for mathematical literacy: (1) that students learn to value mathematics; (2) that they become confident in their ability to do mathematics; (3) that they become mathematical problem solvers; (4) that they learn to communicate mathematically; (5) and that they learn to reason mathematically (NCTM, 1989). The NCTM position statement on language minority students (1994) further clarifies that, "Cultural background and language must not be a barrier to full participation in mathematics programs preparing students for a full range of careers. All students, regardless of their language or cultural background, must study a core curriculum in mathematics based on the NCTM standards."

The goals articulated in the NCTM standards have special implications for math teachers who are working with literacy students. While these students have had many experiences outside of school, most of these experiences have not prepared them for success in formal classroom settings. Math teachers can make math meaningful for literacy students by designing instructional activities that build upon students' real life experiences. Lessons that provide challenging problem-solving activities at which students can succeed help to build their reasoning and problem-solving skills, as well as their confidence. For students to learn to communicate mathematically, they need opportunities to hear math language and to speak and write mathematically.

NCTM Standards and Effective Instructional Strategies for Literacy Students

In 1991, NCTM produced a companion document to the curriculum standards. *Professional Standards for Teaching Mathematics*, which provides guidelines for teachers to design an environment in which all students will develop mathematical literacy (NCTM, 1991). The guidelines require significant changes in classrooms for literacy students. Five of these changes are described here.

1. *Select mathematics tasks that engage students' interests and intellect.*

Although the math concepts for literacy students may be at a basic level, the interests and intellectual abilities of these students are not. Selecting tasks that can bridge these discrepancies in ability levels is a challenge for math teachers. For example, in a lesson on calculating percentages, younger students might calculate the percentage of tax on a bicycle, while older students may use their pay stubs to calculate percentages of various categories of withholding.

2. *Orchestrate classroom discourse in ways that promote the investigation and growth of mathematical ideas.*

Orchestrating discourse for literacy level ESL students requires the teacher to attend to teaching English in the content area, which includes both the language specific to math and additional English language skills. For example, when teaching that an obtuse angle is greater than 90 degrees, the teacher will not only have to teach the vocabulary word *obtuse* but may also have to teach the use of the *-er* suffix to show comparison in the word *greater*.

3. *Use, and help students use, technology and other tools to pursue mathematical investigations.*

Many literacy students are unfamiliar with the basic tools associated with mathematics such as rulers, protractors, calculators, and computers, and need opportunities to make optimum use of these tools. When working on estimation of lengths, for example, students can use both standard and metric measuring tools to find things that measure approximately one centimeter, one decimeter, one meter, one inch, one foot, or one yard. They can then use these items to estimate the length of other objects in the classroom, check their estimates with the actual tools, and use calculators to find the percentage of error in their estimations.

4. *Seek, and help students seek, connections to previous and developing knowledge.*

To make connections with students' prior experience, teachers must become familiar with the backgrounds of their students. Working in collaboration with other content and ESL teachers will help the math teacher provide connections with the knowledge students are developing in other classes. When students are studying data analysis and graph making, for example, the math teacher can collaborate with science or social studies teachers to build connections with work in those classes.

5. *Guide individual, small-group, and whole-class work.*

Literacy math students benefit from a variety of instructional settings in the classroom. The teacher must guide students through individual, small-group, and whole-class activities. The introduction of a new set of vocabulary or manipulatives to the whole class, for example, can build listening and responding skills. Small-group work allows students to use language to talk about the math tasks at hand while they solve nonroutine problems. Individual work settings ensure that all students process lessons at their own rate of learning.

Designing Appropriate Curricula

In order to revise math curricula for literacy students, schools must address such as these:

- Who are our literacy students, and why are they unsuccessful in our present math courses?
- What is the most efficient way for students with limited time in school to learn what their classmates already know?
- How should math teachers incorporate language into daily lessons?
- Why is it appropriate to separate literacy students from other math students for a time?
- How should literacy students' understanding of math be assessed?

Responses to these questions should be used to guide curriculum development by educators from both math and ESL/bilingual backgrounds who are knowledgeable about both the school district's math objectives and the needs of second language learners from various age groups. Math instructors judge the relative importance of existing instructional objectives and, along with ESL/bilingual personnel, develop specific teaching strategies.

Clustering Objectives

Literacy math classes aim to teach a number of years of conventional math classes in a condensed period of time. In many cases, it is appropriate to cluster similar learning objectives across grade level boundaries. These clusters of objectives make the most efficient use of students' time in the literacy math class and also recognize that, often, older students do not require as much time to master objectives normally taught in earlier grades. In addition to saving class time, the clustering of objectives reduces the artificiality of structuring lessons where, for example, students only solve problems that involve numbers less than 100 and do not require regrouping.

Clustering objectives also offers opportunities to integrate a variety of math strands into one lesson. In a geometry unit, for example, a group of students may estimate the cost of carpeting the classroom. The objectives for the lesson would read, "Identify the space inside a plane shape as its area. Find the area of simple polygons." In order to carry out the activity, students also demonstrate their understanding of these objectives: measure lengths of objects using customary units; multiply whole numbers, regrouping as necessary; multiply whole numbers by decimal numbers. These math skills are being used by students in a real life setting to solve a problem while mastering another objective. The teacher can assess mastery of the previously taught content and reteach where necessary while continuing to move through the curriculum.

Three Important Variables

The essential math objectives identified by local school jurisdictions should remain unchanged for literacy math students. In literacy math curricula, however, the objectives are clustered and condensed, modifying the scope and sequence. Next, specialized teaching strategies are developed. All the strategies take into account students' ages, English proficiency, and developmental levels.

Students' Ages. Innovative strategies need to be developed for 17 year-old students with beginning English skills, as well as for fourth graders whose first school experience is in an American setting. Older students benefit particularly from math curricula that take into account their previous life experiences, such as problems involving money or their new school environment. For example, high school students who are studying ordinal numbers could be given practice identifying the periods of their school schedules or explaining the order of their lockers in the hallways.

The fourth grade math literacy student faces a smaller developmental gap with peers, yet may still need a period of specialized instruction. The texts and materials that native English speakers use to learn about ordinal numbers may not interest a student whose previous learning experience has never originated in books. Instruction with concrete experiences, especially incorporating math manipulatives, are effective bridges to formal math class education for literacy math students of all ages.

Students' English Proficiency. In a lesson on ordinal numbers, beginning proficiency students could complete an oral activity combining their understanding of colors with identification of the order of colored objects demonstrated by the teacher on an overhead projector. More advanced students could describe the exercise in writing. In general, less proficient learners depend more on the teacher or other students to model expected work and class behavior. A literacy math classroom will have a different look because it is enriched with extra attention to language. Charts with important vocabulary and language structures fill the walls, along with writing by the teacher and students.

Students' Developmental Levels. Multiple learning strategies are necessary to reach both those students who show understanding of objectives after just a few activities and those who may need continued reinforcement. Literacy math teachers report that they are constantly revising curricular objectives to break them into smaller, simpler pieces, and revising directions to incorporate previously studied vocabulary and activities. Many teachers also modify their overall teaching plan by spiraling out of an objective before it has been mastered by many in their classes, then returning to it after a period of time spent working in another area. For example, after a week spent on a unit on mental math and estimation, the teacher could redirect the class with individualized lessons on operations, incorporating the estimation skills students learned in order to predict their answers. When they return to the estimation unit, the practical value of the lesson will be clear.

Assessing Literacy Math Students' Progress

Just as mathematics content and instruction change to meet the needs of literacy students, teachers need to find different ways to assess literacy students' progress in mathematics. The point from which this growth is measured varies greatly from one literacy student to another but is usually far below the math and English levels of their ESL and native English speaking peers. Reliance on paper-and-pencil tests is often inappropriate because decoding the language of a test may hinder students rather than allow them to demonstrate what they understand. The use of a wide variety of assessment methods will provide a more complete picture of each literacy student's progress, patterns of development, or areas of need. Instead of focusing on what students do not know, it is important to focus on ways students can show what they do know. That information can be used to guide instruction. While grades from tests and quizzes have a legitimate place in assessment, they comprise only one part of the total picture of a student's math knowledge.

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This Digest is drawn from *Reforming Mathematics Instruction for ESL Literacy Students* (1993), a National Clearinghouse for Bilingual Education (NCBE) Program Information Guide. In addition to a more in-depth discussion of the information highlighted here, the guide provides sample lessons for teaching mathematics to ESL literacy students. The guide is available on the NCBE home page (http://www.ncbe.gwu.edu).

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